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UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

# ACCIDENT PREVENTION AT A COPPER SMELTER

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BY

E. A. ANUNDSEN

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

# ACCIDENT PREVENTION AT A COPPER SMELTER[1]

By E. A. Anundsen[2]

## INTRODUCTION

The prevention of accidents is considered a necessity at all branches and divisions of the Phelps Dodge Corporation copper-producing operations, and since there is a continual exchange of data on safety accomplishments between the various units, their safety programs are fundamentally similar. Variations in accident-prevention methods result from a difference in emphasis rather than from a difference in the elements themselves. The main copper-producing operations of the corporation are conducted in Arizona and distributed as follows: Copper Queen Branch, mines division, Bisbee, and smelter division, Douglas, Ariz.; Morenci Branch, mines division, Morenci, and smelter division, Clifton, Ariz.; New Cornelia Branch, Ajo, Ariz.; and United Verde Branch, mines division, Jerome, and smelter division, Clarkdale Ariz. As it is not feasible to describe here the safety programs of all branches and divisions, the program at the Clarkdale smelter has been selected for discussion.

The United Verde Branch includes the mine and smelter purchased by the Phelps Dodge Corporation in February 1935 from the United Verde Copper Co. The mine at Jerome and the reduction works at Clarkdale are designated, respectively, as the mine and smelter divisions.

The smelter division employs 350 to 700 men, according to the production schedule. In addition to the usual departments of a copper smelter, the division includes an auxiliary concentrator that operates with a force of 30 to 35 men and a foundry that employs about 25 men. Responsibility for successful management of the smelter division necessarily is accompanied by responsibility for the welfare and safety of its employees.

As the Phelps Dodge Corporation believes in the humanitarian and economic aspects of accident prevention, the safety of its new employees receives a large part of the attention devoted to problems of operation. In keeping with its policy, the actual accomplishment of accident prevention is left largely to the local management.

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[1] The Bureau of Mines will welcome reprinting of this article, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7061." Presented before a meeting of the American Institute of Mining and Metallurgical Engineers, at Tucson, Ariz., Nov. 1-5, 1938.

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## ACKNOWLEDGMENTS

The assistance of C. R. Kuzell, smelter superintendent, P. C. Keefe, safety engineer, and J. C. Harding, employment agent, in the preparation of this paper is gratefully acknowledged. Much of the credit for the development and successful operation of the safety program is due to Mr. Kuzell.

## SCOPE OF SAFETY PROGRAM

The accident-prevention program at the Clarkdale smelter is distinguished by the following:

1. It includes elements in accident prevention not all of which are possessed by or so fully developed in the programs of other companies.

2. The major elements of the program have been subjected to careful analysis, their accomplishments judged, and a relative value[3] attached to each. Emphasis has been placed accordingly.

3. A good accident experience has been attained.

This program has passed through several stages of evolution, and the process is not necessarily completed. At present it embodies the following features: Safety committees, accident investigations, codes of safe practice, systematic plant inspection, foremanship conferences, physical examinations, dust investigations, first-aid training, and miscellaneous safety elements.

### Safety Committees

Safety committees are essential to the planning and execution of a successful accident-prevention program. Every plant employee at the Clarkdale smelter is included in one or more safety committees. Credit for the present plan of safety organization and for much of its success is due to members of the following four committees and to representatives of the Safety and Employment Department:

#### General Safety Committee

The General Safety Committee is divided into two sections: The Foremen General Safety Committee, for all foremen and department heads which meets once a month, the smelter superintendent presiding; and the Departmental General Safety Committee, including all employees below the rank of foreman, which meets monthly in groups, each foreman conducting the meeting of his group. The objectives of the two sections are parallel. They criticize existing practices and conditions relative to safety, furnish safety suggestions, discuss accident-prevention methods, and consider pertinent items from minutes of other safety committee meetings.

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[3] These values have been determined with the full realization that they measure results obtained by purely local application of the program. Different application is likely to produce different values. The objective is efficient administration of the safety program.

## Departmental Committeemen's General Safety Committee

Each individual group in the Departmental General Safety Committee elects a representative to serve for 3 months on the Departmental Committeemen's General Safety Committee. An elected committeeman has the following duties:

1. He conducts monthly safety inspections of his department and prepares a report on unsafe practices, faulty equipment, and miscellaneous hazards observed.

2. He keep department bulletin boards up to date.

3. He assists in investigating and classifying accidents.

4. He observes and corrects any violations of rules and codes.

5. He checks the application of codes and suggests desirable revisions.

## Smelter Investigation Committee

The Smelter Investigation Committee is composed of five members, including one permanent representative from the safety department. Three members are selected from the ranks of foremen or department heads and one from the workingmen's group; all serve a 3-month term. Appointment of the last member must receive the approval of the Employees' Representative Committee.

The Smelter Investigation Committee investigates all reported accidents, whether or not there is personal injury. No injury is too slight to warrant investigation, and it is believed that nearly all injuries are reported. This committee meets weekly and prepares detailed reports on the accidents investigated, classifies the accidents according to cause, determines responsibility, and recommends steps for prevention of similar accidents.

## Branch Safety Committee

Smelter division members of the Branch Safety Committee include the superintendent, chief engineer, master mechanic, chief surgeon, heads of concentration and preparation departments, and representatives of the Safety and Employment Department. Similar employees of the mine division represent it on this committee, and the branch manager acts as chairman. Upon the Branch Safety Committee falls the responsibility of outlining the safety program. At monthly meetings, reports and accomplishments of the various committees are reviewed, results are analyzed, and future policy is formulated on the combined experience of mine and smelter. Although neither mine nor smelter is required to follow an identical plan of safety organization, the exchange of ideas naturally is beneficial.

## Safety and Employment Department

Although the Safety and Employment Department is not a committee, it is represented on all committees. Members of this department edit and distribute copies of reports of meetings, inspections, accidents, and codes of safe practice. They investigate accidents, check action taken on safety suggestion and generally coordinate safety committee work.

The Safety and Employment Department keeps informed on safety activities of other companies and has been instrumental in introducing many desirable features into the smelter program. Pertinent items selected from National Safety Council publications, safety magazines, and other literature are used to maintain interest at meetings. Much credit is due to this department for sustaining interest in safety meetings before the committeqs were organized well enough to be self-operating. Upon the Safety and Employment Department also falls the responsibility of selecting and instructing new employees.

## ACCIDENT INVESTIGATIONS

Recognizing their value, the management at the Clarkdale smelter has carried investigation of accidents beyond the usual limits. Accident investigations are based on the realization that--

1. A detailed story of the accident must be obtained to determine the cause of injury which may indicate the cause or causes of the accident.

2. The cause or causes of the accident must be pursued to the point where positive correction can be applied successfully.

3. Responsibility for the accident must be determined.

4. A means of preventing occurrence of a similar accident must be shown.

The following accident report illustrates the lengths to which investigative activities may have to be carried in fulfilling the above requireme

### Accident Report 1

August 1936

Jose Gonzales, employed as a swamper in the converter aisle, was injured at 12:10 p.m., August 23, while performing his duties as crane swamper.

Nature of Injury

Third-degree metal burns of legs, back, right wrist and arm.

## Cause of Injury

Struck by flying particles of hot converter slag, which spilled from overturned slag ladle.

## How Injury Occurred

The accident which caused this injury was the falling for a distance of 8 feet of a ladle filled with converter slag and the spilling, splashing and spattering of the molten contents over an area of the converter floor approximately 100 feet long and 30 feet wide. The injury consisted of burns from numerous flying, splashing particles of the molten slag.

Other men could have been injured in this accident, perhaps fatally, and it is a credit to the general alertness of the personnel in the department that the results were not more serious. The victim was the only member of the group whose duties necessitated his presence in the proximity of the accident.

Investigation to determine the cause of this accident has been pursued from several different viewpoints. Besides the usual examination and hearing of witnesses, a number of other studies were made. Since it immediately became apparent that the ladle of slag dropped due to the breaking of a 4-1/4 inch shaft in the hoisting mechanism of the crane, the objective of the various studies was to determine the cause or causes of the fracture of the shaft. These studies included: The gathering of historical facts relative to the installation of and the repair work done on the jack shaft which failed; a critical analysis of stresses in the hoisting mechanism from an engineering point of view; a metallographic examination of the broken jack shaft; a chemical analysis of the jack-shaft material; a study of the transportation of ladles of converter slag from a safety point of view; a critical examination of the design and equipment of the converter cranes as a whole. The finding of these investigations would take too much space in this report and are being presented in a separate detailed report which will pertain only to this accident and which will be distributed among those especially concerned or to anyone requesting a copy.

The conclusions arrived at may be summarized as follows: The shaft was installed about 6 months previous to the accident after having been repaired and re-equipped with a new pinion. The shaft had been previously used. The new pinion was slightly oversize on the bore. The surface of the shaft was therefore slightly built up by electric welding and remachined to a size permitting a good pinion fit. It was thought that the material of the shaft was hammered carbon steel. From metallographic and chemical study it was found that the material was carbon steel but that it had been prepared by cold rolling instead of hammering. The chemical analysis disclosed that the phosphorus content of 0.09 percent was about twice the maximum allowance and about three times what it should have been. While the depth of the weld was only 3/16 inch, micro-examination showed that the fracture was initiated at the edge of the welded surface. Macro-examination indicated that the shaft had some time in its previous history been bent close to the point of final fracture and that it had been straightened, previous to the building up by welding and fitting of the pinion above mentioned.

The engineering study of stresses indicated that the fiber stress in the shaft should not be over 3,000 pounds per square inch for the hoisting of a full capacity load when gradually applied. Such a stress indicated a factor of safety of about twenty to one, which should be entirely adequate. Study of practice revealed that occasionally a ladle will drop an inch or two in the bails due to improper engagement; also, that cranemen sometimes pick up a slag ladle with a jerk because for this special operation the bails have been reclining on the lip of the ladle previous to the lift. These shocks cause impact to the mechanism, and while it is believed the multiplication of stress by such a shock is within the factor of safety provided, nevertheless this shock, together with poor grade shaft material, a shaft history of abuse, and a shaft repair practice which may be subject to criticism, was sufficient to cause the fracture.

From the viewpoint of up-to-date crane engineering and safety engineering, the converter aisle cranes of the Clarkdale smelter are deficient in several respects.

## Remedy Prescribed

1. The removal from crane hoist mechanisms of all shafts exhibiting previous abuse such as bending, and also of shafts previously welded at the fitting surfaces in contact with bearings, pinions and gears. The practice of building up bearing and fit surfaces on shafts is not condemned in general, but in hoist mechanisms of the particular design in Clarkdale cranes it is thought advisable not even to take the small chances involved by such welding practice. If some kind of a satisfactory brake could be installed in the hoist mechanism to stop a runaway load, it is believed that there would be no objection to such type of welding repairs mentioned.

2. Campaign to increase the alertness among cranemen, crane swampers and other converter aisle employees with respect to proper engagement of bails on the ladles and elimination of shock in beginning the lifting of loads.

3. Continuation of extreme precaution of the men in the converter aisle to avoid being within the range of splash of falling loads.

4. Investigation of feasibility of a brake close to winding drum.

5. Scrapping of the present cranes in whole or in major part if new converters are installed. The present cranes are deficient in design when the details of design are exposed to the criteria of good modern crane engineering and safety engineering practice.

Classification as to Fault

3. Faulty tools and equipment.
A. Use of machinery not known to be defective.
4. Fault of Supervision.
B. Failure to provide equipment.
D. Selection of improper method of doing work by those responsible for shop repair methods.

Classification as to Cause

1. Burns.
B. Pouring slag, etc.

All **accidents** are classified under the following headings:

1. Fault of injured employee.
    A. Use of tools and equipment known to be defective or unsafe.
    B. Failure to use safety devices provided.
    C. Failure to use proper tools or appliances provided.
    D. Violation of safety rules or instructions.
    E. Improper act or selection of improper method of doing work by workman.
    F. Failure to wear proper clothing or shoes.

2. Fault of fellow employee.
    A. Use of tools and equipment known to be defective or unsafe.
    B. Failure to use safety devices provided.
    C. Failure to use proper tools and appliances provided.
    D. Violation of safety rules or instructions.
    E. Improper act or selection of improper method of doing work by workman.

3. Faulty tools and equipment.
    A. Use of tools, machinery and other equipment not known to be defective.

4. Fault of supervision.
    A. Failure to provide safety devices required.
    B. Failure to provide proper tools and equipment.
    C. Violation of safety rules by boss.
    D. Improper act or selection of improper method of doing work by boss.

E. **Failure** to instruct as to the method of work and hazards.
F. Accidents resulting from faulty design of plant.

In placing responsibility, supervision as now interpreted by the smelter management is not "personal." Nevertheless, supervision is presumed to have ultimate control over two factors--the physical and the human--that are involved in all accidents, both of which must be determined and eliminated if accidents are to be prevented. To classify an accident and injury (personal or material) fully, occurrence therefore is analyzed further under the following headings:

1. Type of injury (location and nature).
2. Instrument or agency of injury, as hot material, mechanical equipment, chemicals, electricity, falling of flying objects, etc.
3. Type of accident, as explosions, falls of persons, burns, contact with equipment, etc.
4. Physical, mechanical, or material condition causing the accident:[4]
    A. Faulty guarding.
        a. Ineffectively guarded.
        b. Unguarded.
    B. Poor housekeeping.
        a. Improperly piled or stored material.
        b. Congestion.
        c. Dirty or debris-littered walkways.
    C. Defective or improper equipment.
        a. Miscellaneous material and equipment.
        b. Hand tools.
        c. Mechanical equipment.
        d. Electrical equipment.
    D. Unsafe building conditions.
        a. Fire protection.
        b. Exits.
        c. Floors.
        d. Openings.
        e. Miscellaneous.
    E. Improper working conditions.
        a. Ventilation.
        b. Sanitation.
        c. Light.
    F. Faulty design.
        a. Plant.
        b. Equipment.
        c. Processes.
    G. Improper dress or apparel.
        a. No goggles, gloves, masks, etc.
        b. Unsuitably long sleeves, high heels, turned cuff, defective.

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[4] After H. W. Heinrich.

5. Human cause, or man-failure cause of accident.[2]
    - A. Faulty instruction.
        - a. None.
        - b. Not enforced.
        - c. Incomplete.
        - d. Erroneous.
    - B. Inability of employee.
        - a. Inexperienced.
        - b. Unskilled.
        - c. Ignorant.
        - d. Poor judgment.
    - C. Poor discipline.
        - a. Disobedience of rules.
        - b. Interference by others.
        - c. Fooling and horse-play.
    - D. Lack of concentration.
        - a. Attention distracted.
        - b. Inattention.
    - E. Unsafe practice.
        - a. Chance-taking.
        - b. Short cuts.
        - c. Haste.
        - d. Wrong method.
    - F. Metally unfit.
        - a. Sluggish or fatigued.
        - b. Violent temper.
        - c. Excited.
        - d. Worried.
    - G. Physically unfit.
        - a. Defective.
        - b. Fatigued.
        - c. Weak.
        - d. Sick.
    - H. Other causes.
6. Fault or responsibility, with actual parties named if advisable.

The investigators are required to use this classification in analyzing cidents, and it is evident from a study of these six general factors that e investigators are led to distinguish between the injury and the accident. e severity of the injury is often a matter of luck, and there may be several pes of injuries suffered concurrently by one or several victims of one cident.

When analyzed under the headings of this classification, all accidents ow a definite connection with supervision, therefore "shelving" responsi- lity by charging the accident entirely to an employee or fellow employee prevented, and correction of the fault is automatically assigned to those tually having power to accomplish it--the operating staff.

All cases of personal injury are investigated by the Smelter Investiga- on Committee; this applies to slight cuts and scratches as well as to more rious injuries. Not only are slight cuts and scratches considered tentially serious, but it has been found that the severity of the injury not always a measure of the hazard. The person who receives a cut or atch may have been no farther than an inch or a second from death.

There are also accidents not inflicting personal injury but resulting delay or in damage to equipment or material. These are investigated be- use they are expensive and are potential injury hazards. Such investiga- ns have uncovered defects that under less favorable circumstances might e caused serious injury. Two accident reports of this type combined with t selected for the previous example gave rise to the following order, which istrates the importance of investigating accidents causing no personal injury:

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esignated by Heinrich as the "supervisory cause."

August 4, 1937

SUBJECT: General order pertaining to gas and electric welding practice.

Experience gained from investigations of several accidents during the past year has led us to advise that considerable caution be exercised in the repair and reconditioning of certain machine parts in which either electric or acetylene welding takes part. The experience and the conclusions are now sufficiently definite to justify the following order:

The repair or reconditioning of steel shafts, axles, or other members of machines, cranes, locomotives, cars, and other vehicles, through building up of surfaces by welding or joining of parts of welding, shall not be permitted. This prohibition applies to those parts which in service are subjected to repeated dynamic stresses, such as shocks, strong vibrations, or alternation of stresses, either slow or rapid, particularly if a possible failure of the welded parts might cause personal injury, property damage, or expensive interruption of production. In such cases where failure of the parts will not result in personal injury, property damage, or expensive shut-downs, welding may be permitted, but only with the approval of the master mechanic, chief engineer, or superintendent.

Several illustrations of the amazing effect of welding of parts which should always be fatigue-resistant will be given below to illustrate the danger of such practice:

> Case 1. A small spot weld, about the size of a 25-cent silver coin, was made electrically on the surface of a V. T. & S. ore car axle of forged steel 7 inches in diameter. The spot weld was made for the purpose of attaching a small chain for convenience in rotating the axle during reconditioning of the wheels in the shop, and was applied on the surface at about the middle of the axle. The axle failed in service, causing a derailment and property damage amounting to about $1,600. Investigation disclosed the fact that a fine fatigue crack started in the spot weld and gradually, under the influence of repeated bending strains every time the wheels revolved, progressed more than half way through the axle, finally producing sudden and complete rupture.
>
> Case 2. - An axle broke in service under the tank car of the Mallet locomotive of the V. T. & S. Railroad. The damage was slight, because the equipment was in the yards and running light at the time. Investigation showed that the surface of the axle at the wheel fit had been built up by electric welding, and then remachined to fit the wheels. A fatigue crack started at the edge of the

wheel, circumferentially, and had proceeded slowly and gradually toward the center of the axle, until only about 10 percent of sound metal remained, which suddenly failed in service.

Case 3. A jack shaft in the hoist mechanism of a converter aisle crane failed, with the result that a ladle of molten slag dropped and spilled, causing severe burns to one man. The investigation disclosed that the jack shaft had at a previous date been re-equipped with a new pinion. As the pinion did not fit tightly enough on the shaft, the surface of the shaft was built up with electric welding and remachined to make a tight fit. The break started with a fine crack at the edge of the welding, gradually proceeded at least half way through the shaft, and finally failed as above described.

These **cases** are cited to emphasize the disastrous results which may occur from even an apparently insignificant amount of welding on the surface of such parts. In any of the three cases mentioned, the loss of life and property damage could have been of considerable magnitude.

It is recommended that all such parts which have been welded in the past for conditions which would be in violation of the above rule, and which parts are still in service, should be taken out of service, or their condition ascertained by a careful inspection at frequent enough intervals to prevent the occurrence of accidents. The immediate attention of all department heads to this matter is requested. Doubtful cases should be discussed with the master mechanic, the chief engineer, or the superintendent.

Signed:
Superintendent.

Incidentally, responsibility for the above accidents was placed directly
the general staff, from the mechanical department upward. Their position
not ameliorated by lack of knowledge concerning this peculiar effect of
ding; quite the reverse, the need for knowledge to meet all contingencies
emphasized.

From 1935 to 1937, inclusive, 854 personal-injury accidents were in-
tigated. Of this number, 19 accidents resulted in lost-time injuries, and
caused personal injuries without loss of time. During 1937, 112 accidents
t did not result in personal injuries were investigated. Thorough
lysis of each accident is believed to have a far-reaching effect, and the
agement feels that the results obtained more than compensate for the time
expense of investigation. The principal accomplishments are:

1. Determination of the true cause of the accident and description of the essential preventive measures place the responsi-

bility for prevention of similar accidents on a certain individual or group of individuals.

2. The investigation forcefully instills safety consciousness into the individuals directly affected--the witness, the victim, the immediate supervisor of the latter, and the committee members.

3. Publicity of a reasonable type given to findings has a similar, if less forceful, effect on the entire personnel.

4. Unbiased placing of responsibility for accidents and accident prevention encourages employees to adopt a more cooperative attitude toward the latter. There can be no feeling of persecution where committeemen render impartial judgment phrased in temperate language, and the responsibility falls as readily on supervisors as elsewhere.

5. Thorough and determined investigative work presents to all a most convincing argument that safety is of first consideration.

## CODES OF SAFE PRACTICE

Early in the safety campaign, accident investigations began to roll up an impressive score against "supervision." The dismay of individual supervisors at the weight of responsibility, which they felt was not entirely justified, is understandable. Previously, a foreman could be expected to assume a "reasonable" obligation for the safety of a new employee, but this liability was automatically reduced as the employee's experience increased. An "experienced" man who had been in the employ of that foreman for a long period was believed capable of taking care of himself.

The error of this belief was exposed, and it was shown further that neither this man nor the foreman necessarily was reliable in selecting the safest or most efficient method of work; nor were higher officials always infallible in this respect. Therefore, it became obvious that if the foreman was to discharge his end of the accident-prevention program successfully, he and his men must be provided with something more than general safety rules, that is, a specific and detailed guide describing the correct method for each operation they performed. Accordingly, selected officials were given the task of studying operations with a view to making "job analyses" and preparing the necessary guide. An outline was developed, and to date a "code of safe practice" has been drawn up covering 42 separate operations. Some codes are in the process of revision or have already been revised. The time and work required on these codes proved surprisingly great; however, the benefits derived were equally astounding, and the development and use of these codes are now considered among the greatest single accomplishment in the smelter accident-prevention program.

The labor involved in compiling codes of safe practices is indicated by the fact that approximately 135 different references from some 25 sources ave been employed so far. National Safety Council Safe Practices pamphlets re used extensively for reference, but other data have been obtained from a ariety of sources. At any rate, no code is prepared without a previous tudy of all available published information on the subject.

Codes of safe practice covering the following occupations and operaions have been adopted.

Assay department, bucking room and assay office.
Blasting at converter smoke chambers (revised).
Blasting at the discharge doors of primary crusher receiving bins.
Blasting reverberatory furnace bottoms.
Blasting at the roaster storage bins.
Boiler valves and accessories--operation and repair.
Blowdown of locomotive boilers and use of boiler compound.
Coal plant.
Converter-department, cranes maintenance men.
Converter-department, mechanical maintenance men.
Converter-department punchers.
Converter-department skimmers.
Converter-department swampers.
Cottrell power house.
Engineering department.
Explosives; supplementary rules for transfer, storage, and use.
Feed-water pumps and feed-water lines.
General plant inspection (revised).
Industrial haulage (includes separate codes for five haulage operations).
Industrial haulage locomotive and equipment maintenance men.
Inspection of diamond soot blowers on waste heat and direct-fired boilers while in service.
Installation, operation, and maintenance of water-cooled dampers in boiler inlet flues.
Maintenance-of-way department (V. T. & S. Railroad).
Motor-vehicle drivers and garage attendants.
Power-house switch-board operators.
Reverberatory-department clean-up crew.
Reverberatory-department coal burners and blowers.
Reverberatory-department converter slag spoutmen.
Reverberatory-department gas testers.
Reverberatory-department matte tapping.
Reverberatory-department skimmers.
Reverberatory-department slag skimming.
Roaster clerks.
Smelter section gang.
Switch inspection (R.R.).
Waste-heat and direct-fired boilers--putting in and out of service.
Welding practice, gas and electric.
Wire ropes on converter cranes.

Special codes for the purposes indicated include:

Instruction and description of the roaster plant sampling device at the discharge chute of conveyor 15.

Instruction for the operator of the roaster feed sampling device at the discharge chute of conveyor 15.

The outline used in preparation of codes follows:

## Outline To Be Followed in Preparing and In Criticizing Safe Practice Codes

I. REFERENCES
   A. Pgs.__________________Rule Book__________________
   B. Safe Practice No._______________________
   C. National Safety Council Pamphlet No._______________
   D. A.R.A._________________________________
   E. U. S. Departments_______________________
II. DESCRIPTION OF JOB
   A. Objective.
      1. Statement of objective.
      2. Services to be performed.
      3. Services not to be performed.
   B. Hazards.
      1. Statement of obvious hazards.
      2. Statement of hidden hazards.
III. CREW, DUTIES AND RESPONSIBILITIES
   A. Personnel.
   B. Qualifications.
   C. Training for job.
   D. Reception of new employee or apprentice.
   E. Duties of crew members.
      1.
      2.
      3.
      4.
   F. Apparel.
      Hat.
      Shoes.
      Gloves.
      Goggles.
      Respirator.
      Leggings.
      Spats.
      Aprons.
      Clothing.
         Kind.
         Fit.
         Condition.
         Prohibited items.
            Ties.
            Low shoes.
            Finger rings.
      Special equipment.

IV. EQUIPMENT AND MATERIAL
   A. List of machinery and capacity.
   B. Tools--both for operation and repairs.

V. PREPARATION AND HOUSEKEEPING
   A. Inspection of equipment.
   B. Illumination.
      1. Natural (windows).
         (windows, washing).
      2. Artificial.
         a. Economy in use.
         b. Kind and amount of lamps.
         c. Prompt replacement.
         d. Location of control.
         e. Schedule for use.
   C. Ventilation.
      Fresh air.
      Temperature.
      Air pollution.
   D. Sanitation.
      Hygienic.
      Drainage.
      Garbage--refuse disposal.
   E. Fire protection.
      1. Mechanical.
      2. Chemical.
   F. Lubrication.
      1. Methods of application.
      2.
   G. Housekeeping.

VI. PROCEDURE AND PRECAUTIONS
   A. Job---x.
   B. Job---y.
   C. Job---z.
   In all above job precedures do not fail to discuss signals, utilizing the following outline,--
   D. Signals.
      1. Signal devices.
         a. Type.
         b. Location.
         c. Authority to use.
         d. Code.
      2. Signals by hand.

VII. COORDINATION WITH OTHER JOBS
   A.
   B.
   C.

VIII. PROCEDURE IN EMERGENCIES
   Such as:
   A. Power failures.
   B. Controller and brake failure.
   C. Missed holes.

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D. Low water in boilers.
E. Fires.
F. Bad air.
In lettering and numbering paragraphs, headings, and subheadings, the letters and numbers should be used in the following sequence:

- I.
  - A.
    - 1.
      - a.
        - (1)
          - (a)
            - aa.
              - (aa)

To make the details of the codes clearer many of them contain illustrations of equipment borrowed from manufacturers' specifications or prepared locally. This applies particularly to the codes governing inspections, which are described later.

After the problem of code preparation has been largely solved, the difficulties of familiarizing the employees with the objectives, hazards, duties, responsibilities, equipment, tools, apparel, safeguards, etc., that attach to his job still exist. Although the codes have been made as brief as is practicable for complete coverage, they still are too long and detailed for rapid assimilation. To familiarize the employees with the codes, combined study, verbal instruction, and practical training are employed, with a definite follow-up schedule of examination.

## SYSTEMATIC PLANT INSPECTION

Codes of safe practice include one for general plant inspection, which describes the minimum safety requirements to be considered in such an inspection and covers the subjects of yards and approaches, buildings (physical condition, inside and out), working conditions (ventilation, light, sanitation), precautions against fire and explosion, fire fighting equipment, building equipment (cranes, elevators, etc.), storage and handling of materials, condition of ladders, electrical equipment, machinery, hand tools, clothing and first-aid equipment.

Each departmental committeeman is provided with a general inspection sheet (revised), covering the same items in outline form for making monthly departmental safety inspections. The items to be inspected are arranged on the inspection sheet in question form so that a yes or no answer suffices. However, when substandard conditions are noted, the committman describes the nature of the condition on the opposite blank page, together with suggestions or recommendations for its correction. Thus the code is the target, and "errors" are recorded on the monthly inspection sheet.

Inspection codes of more specific application have been prepared on such subjects as wire rope, bridge cranes, power-house switchboard, and related equipment. These codes are provided for reference where the committeeman's field of inspection embraces such special items. Supplementary inspection sheets are provided to record the "errors." Inspection codes and outlines are also provided for special equipment that may require daily, weekly, or monthly inspection by the operator. It is worthy of note that space is provided for a sworn affidavit by the inspector on monthly inspection forms used for the inspection of equipment whose failure would be dangerous.

Not the least important of the safe practice codes pertaining to plant conditions and equipment is that prepared for the engineering department; it is best described by quoting its foreword:

> The operations carried on in the engineering departments are concerned largely with the design and choice of equipment and structures. Little or no hazard is involved in these operations themselves, yet serious hazards are apt to be created through the neglect of safety in design and choice of new equipment.
>
> It is impracticable to draw up a detailed code specifying standard safe practices in respect to all designs and equipment within the scope of engineering department operations. Much detailed material has already been published covering this field and is readily available.
>
> Therefore, the "Index of Standard Practices and Equipment" lists the item on which safety information is desired, together with the authority or reference containing such information. This, in effect, is the safe practice code. The following references are required:
>
> 1. A bound and indexed set of Safe Practice pamphlets as published by the National Safety Council.
> 2. Copies of any special industries pamphlets pertaining to any operation within the scope of the branch activities.
> 3. Copies of all plant safe-practice codes.
> 4. Any other pamphlets referred to in the index.
>
> The "Check List for Structure and Plant Design" has been drawn up to assist in checking over general drawings and lay-outs for hazards. Each drawing so checked shall bear evidence that this has been done.
>
> The "Check List for Equipment" has been drawn up to assist in checking all new equipment to guard against the introduction of new hazards into the plant. Each requisition for equipment covered by this list shall be so checked before approval can be granted for its purchase.

Unfortunately, the length of the inspection codes and inspection sheets prohibits appending them to this publication. However, their comprehensiveness is worth emphasizing. If any pertinent items are missing from these inspection codes and sheets, their absence has escaped notice so far.

Two definite accomplishments of these inspections are numerous plant improvements and increased safety consciousness among those making the inspections. Since there is a committeeman on each shift of each department, and each committeeman is limited to a 3-month tenure, a sizable number are enlisted each year, thereby participating in this form of safety education.

## FOREMANSHIP CONFERENCES

The shortcomings of supervision are quickly "spotlighted" by any analytical investigation of accident causes, and a diagnosis of these shortcomings brings to light some interesting facts. For example, an individual becomes a "boss" because his work has shown a certain understanding and skill above the average. He rises to foremanship because his accomplishments as a boss are above average for bosses. If his upward progress continues, his qualifications are still measured by comparison with the average qualifications of men in his position. Unfortunately, "average" is an uncertain basis for comparison, and a man having qualifications above average is not necessarily a competent supervisor when judged by more consistent standards.

If a list of the essential characteristics for good foremanship is placed side by side with a list of the same essential characteristics actually displayed by a given foreman, the latter is likely to fall surprisingly short of expectations.

Nevertheless, this individual probably has the desired essential characteristics, and foremanship conferences over the United States are now a rather general means of developing them. Those conducted at the Clarkdale smelter differ from the usual training in two respects: They are both self-starting and self-operating. A foremen's club organized by the smelter supervisors conducts the conferences, furnishing its own conference leaders. Subjects for discussion are partly of spontaneous origin and partly suggested by a published course of training. Topics covered in these meetings include the following:

Duties and responsibilities of a foreman.
Qualities of leadership.
Application of discipline.
Fundamental reasons for safety work.
Using facts to prevent accidents.
Selecting, training and checking the performance of new employees.
Purpose of physical examinations.
Relationship of good foremanship to safety.
Accomplishments of informal group safety meetings.
Safety suggestions.
Safety rules.
Safeguards and good housekeeping.

Foremanship conferences represent one phase of safety education, blending with the safety-education program as a whole. Concrete evidence of accomplishments, therefore, is difficult to establish. However, such training does much to maintain a high level of safety consciousness among foremen--a never-ending problem in any safety program.

## PHYSICAL EXAMINATIONS

A complete physical examination is required for employment at the Clarkdale smelter. This is of the usual thorough type, and visual or other defects that might affect the wisdom of exposing the candidate to certain hazards are carefully noted.

Thus, defects that do not prohibit employment may still influence the selection of the type of work to which a new employee can be assigned. For example, his job assignment may be decided through the use of visual data, as follows:

Employees are classified in four groups based upon the percentage of normal vision that they possess. Smelter work is also divided into four classifications based upon the percentage of normal vision necessary for safe and efficient performance of the work. An employee having "A" (normal) vision can perform work in "A", "B", "C", or "D" classification. An employee having "B" vision may work at tasks in the "B", "C", or "D" groups, and an employee with "D" vision can work only at "D" tasks. Employee vision classifications may be based upon corrected vision if the work is such that glasses can be worn.

Similarly, information obtained through physical examination can be used for job assignments where other defects are involved. Transfers are based upon hearing difficulties, nasal defects, heart or lung ailments, physical deformities, and general health conditions. The use of such information is considered extremely important in improving the general welfare of the employee and is also believed to have a definite bearing on the prevention of accidents.

## FIRST-AID TRAINING

The third annual first-aid course was recently completed at the smelter. Approximately 90 percent of the employees and nearly 100 percent of the supervisory force completed the training and passed the examination. Large-scale cooperative first-aid training was initiated in the fall of 1935 following an instructors' course conducted by a Bureau of Mines representative. The 35-hour instructors' course was conducted on company time, and after instructors had taught the one class necessary to earn their Bureau of Mines instructor's certificate, they were paid 75 cents per hour for additional classes conducted. The first-aid course consisted of 15 hours training by these instructors, and a 2-1/2-hour examination conducted by a Bureau representative. Employees were required to attend first-aid classes on their own time, without pay.

In 1936 the plan was revised to the extent of offering the following alternatives to the employees:

1. They could complete the standard first-aid course, and on passing the examination would be paid $5.00; or

2. They could complete a special 6-hour course covering the subjects of shock, artificial respiration, bleeding, and general handling of injured persons, and pass a special examination on these subjects but would be entitled to no remuneration; or

3. They might stand a special examination covering the subjects of the 6-hour course. Failure in the examination would necessitate their taking the 6-hour course. No remuneration was offered for this alternative.

Approximately 92 percent of the smelter employees chose the first alternative.

First-aid examinations in 1935 included questions and demonstrations on subjects covered in training. However, half of the examination period was spent on accident-prevention discussions aimed primarily at the mythical "unavoidable" accident. Some lively debates developed, and it was felt that the training and discussions had a definite influence in altering the "die-hard" attitude of numerous individuals toward accident-prevention measures.

In 1936 examinations followed a similar trend, and it was observed that the attitude of both employees and supervisors had undergone a distinct reversal on the subject of the "unavoidable" accident. Moreover, the intent of accident-investigation processes was thoroughly aired so as to leave no misunderstanding as to their purpose.

In 1937 the first aid course was altered at the request of employees who desired reasonable variety in their annual training. The new course covered the same subjects in the same order but did so by means of contest-type problems. Instructors received special training preceding this course, and the men felt that the change was definitely for the better. Examination consisted of contest problems, judged with the standard discount sheet, and teams were required to score an average of 85 percent or higher on two problems. The accident-prevention discussion was directed toward cuts, scratches, and eye injuries.

The progress of the accident-prevention program was clearly discernible in the discussions conducted. In the 2-year interval between the 1935 and the 1937 examinations, safety consciousness had made great advances. The worth of first-aid training probably will not be determined accurately, but it seems reasonable to suppose that its influence may have extended into nearly every phase of the safety program.

As for the direct application of first-aid knowledge, there is no record of its use to any substantial extent inside the plant. Several cases of successful first-aid application to injuries sustained outside the plant have been reported.

## MISCELLANEOUS

In the attempt to reduce accidents, attention was directed also toward the more obvious elements essential to the success of a safety program. Such items as safe wearing apparel, safety suggestions, safety advertising (posters, exhibits, signs, posted rules), and safety devices therefore have received consideration. In fact, accident-investigation findings have placed new importance on such factors so that some have been incorporated into the codes of safe practice. The handling of these items deserves special mention.

### Safe Wearing Apparel

The statement, "Hats, shoes, gloves, goggles, and respirators must be of approved type", appears in such codes of safe practice as do not list special apparel. The word "approved" refers to the approval of the management. Items included in the approved list are qualified further as follows:

Dust respirators must bear the approval of the Federal Bureau of Mines.

Hard hats must be of standard manufacture and of nonmetallic construction.

Shoes must have high tops and protective toes, the latter preferably metal.

Goggles must have shatterproof glass lenses, and frames must be of nonmetallic construction, except where spectacle-type goggles are permitted. For some work, rubber or bakelite frames are specified definitely, depending upon visual requirements, heat, and gas conditions, or electrical hazards. It is required further that every employee have on his person a pair of goggles suitable for his work.

Gloves of canvas, leather, or asbestos are specified according to the operations performed. The use of open, gauntlet-type gloves is prohibited.

Additional items of apparel are described as follows:

Leggings must be made of fire-proof duck.

Leather spats must be of soft chrome leather with flares of stiff leather at the bottom.

Aprons must be of a standard type suitable for the work to be performed.

Babbiting helmets are required for all babbiting operations. These are furnished by the company and therefore the type used is predetermined.

Woolen ear plugs must be used on burning, welding, and other operations where flying sparks are a hazard.

Woolen coveralls, furnished by the company, must be worn for certain types of work.

Leather pads, faced with metal, are specified for handling hot, rough, or abrasive material.

The wearing of woolen shirts, underwear, and trousers is encouraged where there is danger of contact with hot material. Under similar conditions, sleeves must extend over the open end of gloves, and trouser legs must be worn over spats or leggings. For some work cuffless trousers are specified. Jumpers worn where there is danger of flying sparks must be tight fitting around the neck. Wearing ragged or torn clothing and carrying waste or similar material partly exposed in clothing pockets are generally prohibited. Wearing finger rings, neckties, and low shoes is prohibited in most departments.

Such items as goggles, spats, leggings, respirators, and welders' gloves are furnished by the management. All other apparel is furnished by the employee. However, hard hats damaged in the course of duty are replaced by the management.

## Safety Suggestions

The value of a safety suggestion depends chiefly upon the consideration, acknowledgment, and application of the suggestion. It serves primarily to correct faulty working conditions. If, however, a suggestion is ignored, it makes little difference whether it is practical, since an opportunity to establish friendly cooperation with the employee is lost. At the Clarkdale smelter, acknowledgment of a safety suggestion is a primary consideration. The suggestion is immediately referred to the proper authorities and if practical it is carried out at once--a sufficient acknowledgment. If impractical, the employee is informed why his contribution cannot be used.

Main sources of safety suggestions are departmental safety inspections, departmental safety meetings, and accident investigations. However, many suggestions are offered directly to supervisors or to the safety and employment department. Virtually all plant physical improvements in the interest of safety and efficiency are direct results of safety suggestions. Many improvements in working practice also can be credited to this feature of the safety program.

## Safety Advertising

Visual appeals for safety are presented by National Safety Council posters appearing on some 25 bulletin boards throughout the plant. Goggles and other articles of apparel damaged in accidents are exhibited near the safety office and at safety meetings. Warning signs are much in evidence, and posted rules for operation or use of equipment are used extensively. In addition, basic regulations, violation of which is cause for discharge without further notice, are posted at the time office where they are certain to be observed; these regulations are the core of the disciplinary system and are brief enough to be understood readily. Those applying to safety read as follows:

1. Indulging in "horseplay", or conducting himself in a manner which might lead to injury to himself or fellow employees.

2. Sleeping while on duty.

3. Introduction, possession, or use of intoxicating liquors or habit-forming drugs on the property of the company.

4. Failure to immediately report accidents or personal injuries occurring on duty, or claiming compensation for injuries received while off duty.

5. Falsifying regarding accidents occurring on duty, or when applying for employment, or while undergoing the physical examination for employment.

6. Harboring a disease that on account of the employee's own carelessness will endanger fellow workmen.

7. Failure to put up safety signs when working on electric-powered apparatus, or the removal of such signs without proper authority.

8. Deliberate, willful, or flagrant violation of definitely established safety rules.

For other offenses not included in the above list, an employee shall not be discharged without first having been notified that a repetition of the offense will make him liable to dismissal. Such notice shall be given by the foreman or boss in charge of the work, and advice thereof forwarded to the employment department immediately.

Any employee who is discharged will be informed as to the reason for his discharge by his foreman or boss.

## Safety Devices and Equipment

Special safety devices and practices developed and applied as the accident-prevention work progressed are too numerous to describe in full. However, some are worth brief mention:

1. Heat resisting, shatterproof glass shields have been attached to converter control cabs to protect skimmers from heat and flying hot material. Similar glass has been placed in cab windows of slag haulage locomotives.

2. A welding-fume collector has been installed to protect welders against fumes and dust from welding operations.

3. Automatic warning signals have been placed at all industrial haulage crossings.

4. A fume-collecting system has been installed in the reverberatory department to draw fumes from the matte tunnels and matte tapping hole during matte tapping operations.

5. Shower baths capable of delivering a heavy spray of water have been installed in the assay office, converter aisle, and reverberatory department for quick removal of corrosive elements from skin and clothing, and quick extinguishing of fires to clothing.

6. Extensive tests by a patented process are being made to locate invisible fatigue cracks in shafts, axles, and other metal parts subject to vibration or shock stresses.

7. To reduce transmittal of skin disease, antiseptic solution containers (foot baths) have been placed at entrances to all shower baths in change rooms.

8. Engineers have designed an enclosed car for calcine haulage to reduce the hazard of hot, flying dust when calcine is loaded and transported. This car is now in the process of construction.

The accident-prevention program should also be credited with the installation of a host of minor safety devices, including numerous guards and railings all of which have increased safety and efficiency of plant operation.

## ANALYSIS OF ACCIDENT-PREVENTION METHODS

Many of the best features of the present accident-prevention program did not mature fully until after July 1936, when it was decided that efforts to prevent accidents must be intensified if the safety program was ever to be a thoroughgoing success. The result was a careful analysis of accidents, and at a special July meeting of the Branch Safety Committee, factors contributing to accidents were diagnosed as follows:

| | Influence, percent |
|---|---|
| 1. Inadequate standards of safe practice. | 60 |
| a. For intermediate, minor or unrecognized hazards rather than for recognized major hazards. | |
| b. For good supervision. | |
| 2. Lack of safety consciousness among all workmen. | 30 |
| 3. Personal inefficiency of some workmen. | 10 |

On this basis, codes of safe practice assumed major proportions as weapons against accidents. They not only appeared to be indispensable in combating cause 1, but they seemed valuable for increasing safety consciousness and the personal efficiency of workmen, thus striking at causes 2 and 3.

At the end of the period July 1936 to July 1937, the smelter-division members of the Branch Safety Committee analyzed the relative effectiveness of accident-prevention methods employed during the 12 months. After studying all elements of the smelter accident-prevention program, this committee arrived at the following conclusions:

## Relative Value of Elements in the Smelter Accident-Prevention Program

### 90 PERCENT FACTOR

### Increased Safety Consciousness--i.e., Convincing Everyone That Safety *Is* First

| Method | Relative value, percent |
|---|---|
| A. Study of practice and elimination of unsafe methods by: | 35 to 40 |
| 1. Written codes. | |
| 2. Good foremanship. | |
| a. Advance planning of work. | |
| B. Better shop and departmental safety meetings. | 20 to 25 |
| C. Systematic plant inspection by workman committeemen which has been productive of visible results.[6] | 15 |
| D. Analytical investigation of *all* mishaps. | |
| 1. Classification. | 15 |
| 2. Publicity on findings. | |
| E. Foremanship conferences. | 5 |
| F. First-aid training. | 5 |
| | 100 |

### 10 PERCENT FACTOR

### Better Physical Conditions, Safeguarding, and Dust Control

| Method | Relative value, percent |
|---|---|
| A. Systematic plant inspection, carefully noted and followed up. | 40 |
| Suggestions in shop and department meetings. | 20 |
| Personal apparel, etc. | 20 |
| Alertness of foremen and department. | 10 |
| Analytical investigation of *all* mishaps. | 10 |
| | 100 |

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[6] In time this factor is likely to be increased, since committeemen assignments are progressive.

The above conclusions apply only to the smelter program and the period indicated. A similar analysis of another safety program is likely to produce substantially different values. For example, at the operations of some companies, first-aid training as a means of increasing safety consciousness may supplant some factors in the preceding outline and may even carry a 40-percent valuation. As a matter of fact, if an earlier analysis had been made at the Clarkdale smelter, first-aid training doubtless would have been accorded greater credit, but much the same effect is now obtained through the more enduring elements of the existing safety program.

## SUMMARY AND CONCLUSIONS

The success of an accident-prevention program depends first upon the whole-hearted determination of the official staff, from the top down, to eliminate accidents, and second on the recognition by the workman of the authenticity of this determination. For this purpose, the management of the Clarkdale smelter has developed a safety program combining a variety of elements of which safety committees, accident investigations, codes of safe practice, and systematic plant inspections are deemed the most effective. These and other elements of this safety program have been described in detail.

The present program is closely related to the programs of other branches and divisions of the Phelps Dodge Corporation and has been influenced also by ideas developed in safety programs of other companies. Operating codes have long been used to good effect by railroads, and these furnished the inspiration for the codes of safe practice developed at the Clarkdale smelter. It is interesting to note that some operating codes dealing with rail transportation are applied to all railroads, and it possible that some of those prepared at Clarkdale could be used to good advantage at other smelters.